Mystic River Watershed Association
Climate-Resilient Riverbank and Ecological Restoration Planning Project
Medford, Arlington, and Somerville, MA

Climate-Resilient Riverbank and
Ecological Restoration Planning Report

March 21, 2017

Prepared for:

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Tables of Contents

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Section 1.0 Introduction and Background

The Mystic River Watershed Association (MyRWA) has requested BSC Group, Inc. (BSC) to assess restoration opportunities along the Mystic River bank, within a specific 4-mile corridor (see Attachment A, Figure 2), in order to facilitate riverbank and habitat restoration and to address erosion problems. BSC evaluated the 4-mile stretch of the Mystic River (Project Corridor) for both small scale and larger scale opportunities to restore riverbank and ecological functioning of the river and adjacent lands. Additionally, MyRWA requested that BSC develop ecological/riverbank restoration planning for the Torbert Macdonald Park and two other areas at a greater level of detail, and that BSC identify opportunities for volunteer involvement in restoration projects. This report is intended to provide a planning-level assessment of ecological restoration opportunities and associated potential long-term management strategies, and results from a coarse-scale screening of the project area. Where appropriate, BSC has identified projects and strategies that have potential to improve the resilience of the Mystic River and adjacent lands to changes in climate that are occurring. MyRWA has received National Fish and Wildlife Foundation grant funds to support this project.

More specifically, MyRWA targeted the following restoration goals for streambank and habitat restoration:

- Reduction of nonnative plants on riverbank;
- Greater wildlife habitat and ecosystem function;
- Improved biodiversity;
- Reduction of inputs of nutrient phosphorous through soil/sediment erosion
- Advancement of ecosystem-based climate resiliency

While this report provides a menu of potential future projects (Section 2 and Attachment D), it is not intended to provide specific design plans, detailed permitting or cost analysis, or otherwise detailed surveys, reporting, or scoping for specific projects.

In preparing for this assessment, BSC has reviewed the Massachusetts Watershed Initiative Mystic River Watershed Assessment and Action Plan (2006) (MRWAAP), the Massachusetts Department of Conservation and Recreation Mystic River Master Plan (2009) (MRMP), as well as the aerial photographs and historical maps included in Attachment B of this Climate-Resilient Riverbank and Ecological Restoration Planning Report. This report is meant to complement these previous reports, provide updated information about specific locations, and add considerations of ecosystem-related climate resiliency to the long-standing community conversation on the Mystic River and adjacent lands. The MyRWA restoration goals listed above are consistent with many of the MRMP project goals (page 4) and conservation objectives (page 77), and the “priorities for action” identified in the MRWAAP. The MRMP and MRWAAP

provide more extensive and detailed historical information, as well as social and ecological inventories, than the scope of this report allows, and should be referred to for a more detailed history of the Mystic River, its watershed, surrounding human communities, human impacts, efforts to counteract those impacts, and social and ecological inventories. These two reports provide proposals for meeting their identified goals, many of which will match, be similar in nature to, and/or complement the recommendations of this report.

This report provides two levels of ecological restoration planning. The first level (Section 2.0) provides a discussion of large-scale "game-changer" ecological restoration and climate resiliency projects or approaches that could substantially improve the ecological function of the Mystic River and adjacent land, as well as general principles of ecological restoration and ecologically-centered climate resiliency planning that can be applied in future decision-making. Recognizing that large scale restoration and resiliency projects often require extensive funding and time, a second level of analysis has been developed that identifies projects that could be implemented with relatively small budgets, and within shorter time frames. The smaller scale project information is presented in the Mystic River Ecological Restoration and Resiliency Opportunities Table (Opportunities Table), (Attachment D).

In preparing this report, the project corridor was reviewed (see Attachment A, Figure 2) from the water side (by boat) and from the land side (by car, bicycle, and foot), and identified specific areas where ecological and riverbank restoration projects could be implemented. Attention was particularly focused on Torbert Macdonald Park (TMP) (Area 18), the Boston Avenue lawn (Area 1), the lawn and beach area on the northeast edge of Lower Mystic Lake (Area 6), and undeveloped land north of TMP (Area 17).

Section 2.0 Mystic River Watershed Ecological Restoration and Climate Resiliency

Ecological restoration is the process of assisting degraded, damaged or destroyed ecological systems to regain healthy and self-sustaining ecological structure and function. Traditionally, this has entailed returning the ecosystem to a historic trajectory (Society for Ecological Restoration International Science & Policy Working Group, 2004). Our changing climate is causing ecological shifts and is impacting the ability of ecosystems either to remain on a historical trajectory, or to be fully restored to a historical trajectory. However, restoration of fundamental ecological processes and healthy ecological structure and function not only remain effective approaches to the management of ecosystems, but are likely to improve the climate resiliency of the ecosystem and surrounding areas. Restoration of ecological processes, structure and function, such as by removing stressors and enhancing biological condition and ecological connectedness, often enhances an ecosystem's ability to be resilient in the face of a changing climate, and in doing so, often enhances the climate resiliency of surrounding human communities.

Often, ecological restoration entails identifying and removing stressors and non-natural disturbance (such as invasive species removal, dam removal, pollutant/contaminant removal, etc.), repairing the abiotic environment, re-establishing native species composition and structure, re-establishing connections to adjacent ecosystems and landscapes, and then allowing natural processes to maintain ongoing, process-based restoration of the ecosystem. Maintaining healthy ecosystem structure, function, complexity, biodiversity, processes and connectedness to other ecosystems supports ecological resistance to invasive species, pathogens, and disease, and ecological resilience in the face of stressors such as climate change, just as maintaining a healthy body supports resistance to disease and stress, and resilience in the face of illness, in a given organism. Ultimately, ecological restoration leads to re-establishment of resilient, self-organizing and self-sustaining ecosystems. Successful long-term ecological restoration is often dependent upon integration of human community needs and values, and when done successfully, leads to greater benefits for both humans and the larger ecosystem.

Human communities are more resilient to climate change when integrated into a landscape that includes healthy ecosystems (Massachusetts Executive Office of Energy and Environmental Affairs Adaptation Advisory Committee, 2011). For instance, human settlements in proximity to healthy and functioning floodplains, salt marshes, and freshwater wetlands generally experience fewer problems with flooding than similar communities with highly impacted aquatic and wetland ecosystems. Likewise, community water supplies and streamflow are less impacted by drought when wetlands in the watershed are protected so that they are able to act as reservoirs for ground and surface water. Coastal communities are buffered from storm damage, sea level rise, and storm surge if coastal and estuarine wetlands, salt marshes, and sea grass beds are healthy and protected. Because they store water on the landscape, wetlands provide localized cooling, which enhances climate resiliency for neighboring humans, wildlife, crops, and native vegetation. Additionally, healthy ecosystems store carbon, and thus contributing to deceleration of global warming and climate change.

Section 2.1 Ecological Restoration and Climate Resiliency Projects - Overview

Several approaches for significant, "game-changing" ecological restoration projects along the Mystic River were discussed, from the Amelia Earhart Dam to the Lower Mystic River Lake (Project Corridor, Attachment A, Figure 2), including having a discussion with staff from the Massachusetts Division of Ecological Restoration. The large-scale projects discussed below are reflective of these conversations. In addition, more easily funded and implemented smaller-scale projects were assessed. A menu of these smaller scale projects and planning level project descriptions is provided in the Opportunities Table and associated Memoranda, (Attachment D, and mapping (Attachment A, Figure 3) that together indicate which projects could be implemented in which locations within the project corridor.

Substantial and successful large-scale ecological restoration projects would simultaneously enhance both ecological and human community health, functionality and resilience to climate change. In identifying and prioritizing potential projects, the principles of ecological restoration and climate resiliency identified in Section 1.0 can be utilized in decision-making processes. In the near term, by implementing the smaller scale projects identified in the text, attachments, figures and tables that follow, cumulatively and over time, greater ecological function and climate resiliency can be achieved in the vicinity of the project corridor.

Following the principles of ecological restoration, consideration of stressors and disturbance to the natural function of the Mystic River and associated floodplain is the starting point for this analysis. Historical aerial photographs and USGS topographic maps (See Attachment B) provide insight into the extent of the historic Mystic River floodplain wetland and salt marsh, as well as the dynamic nature of the river channel itself, prior to human intervention. Over time, humans have controlled the river by hardening riverbanks, filling floodplains and wetlands, constructing the Amelia Earhart Dam, controlling flow, and straightening the channel. As a result of these activities, further changes have occurred, such as the slowing of river flow and associated sediment accumulation in the river channel and the shift from saline-to-brackish conditions/species to brackish-to-freshwater conditions/species, many of which are invasive. Historically, river herring inhabited the Mystic River in large numbers. Currently, some level of anadromous fish passage occurs at the Amelia Earhart Dam when boats pass through, but it is substantially diminished compared to pre-dam conditions. Massachusetts Department of Conservation and Recreation (DCR) staff currently use the dam locking system to facilitate fish passage, because the fish ladder itself is not in good repair (personal communication, Patrick Herron, 11/02/2016). Additionally, the watershed has become increasingly urbanized, increasing paved surfaces and decreasing naturally vegetated areas with associated degradation of water quality and increases in ambient heat. The increases in urban runoff, reduction of forested cover along riverbanks, and the sedimentation of the river channel contribute to warming of river water temperatures. High nutrient and pollutant loading, combined with loss of floodplain wetlands, and warmer water temperatures has led to degradation of water quality, increased eutrophication, reduced dissolved oxygen, and increases in aquatic invasive species such as water chestnut (Trapa natans), Eurasian watermilfoil (Myriophyllum spicatum), and curly pondweed (Potamogeton crispus)). “Game changer” ecological restoration/climate resiliency projects would remove or significantly reduce the aforementioned stressors, and/or provide ecological restoration of ecological function.

Section 2.1.1 Generalized Project Planning Process

For all projects suggested below and in the attachments to this report, a multi-step planning process would be required, likely entailing the following elements:

1. Identification of project goals, in collaboration with stakeholders, property owners, potential partners, community members.
2. Identification of project scope.
3. General feasibility assessment.
4. Development of specific project and design plans and sequencing, including:
    a. feasibility and constructability studies,
    b. stakeholder, community, and volunteer outreach and involvement,
    c. permit planning and implementation,
    d. assessment and resolution of subsidiary issues that are identified during planning process (such as disposal of contaminated sediments, historical, archaeological, and rare species issues, etc.),
    e. define performance standards and measures of project success,
    f. plans for post-construction or post-implementation monitoring,
    g. plans for long-term maintenance, where necessary.
5. Project implementation.
6. Post-project monitoring, assessment and reporting.
7. Long-term maintenance, where necessary.

Section 2.1.2 Generalized Project Permitting Process

The project corridor includes a major historically-tidal river, prior to construction of the Amelia Earhart Dam, and includes land owned by the state and managed by a state agency (DCR). Numerous federal, state and local laws and regulations apply to work within the project corridor. Once a specific project has been selected, and specific project designs are developed, the permit requirements specific to that project will be identifiable. Generally speaking, projects in the Mystic River project corridor should be screened for permits/authorizations required under the following laws and regulations:

- Section 401 Clean Water Act/Water Quality Certification program,
- Section 404 of the Clean Water Act,
- Section 10 of the Rivers and Harbors Act,
- National Pollutant Discharge Elimination System (NPDES) permit program,
- Federal Endangered Species Act,
- Section 106 of the National Historic Preservation Act of 1966,

Flow Management:
Volunteer Opportunities

Science:

Monitoring changes in water temperatures, chemistry, nutrient and pollutant levels, fish communities and vegetative communities, pre and post project.

Community:

Hosting community events to fund-raise and generate community support. Design and build signage to explain the science and value of the project.

- Massachusetts Environmental Policy Act (MEPA),
- Chapter 91 Massachusetts Public Waterfront Act,
- Massachusetts Wetlands Protection Act and associated municipal bylaws and ordinances,
- Massachusetts General Laws Chapter 9, sections 26-27c (Massachusetts Historical Commission - historical and archaeological review/authorization),
- Massachusetts Endangered Species Act,
- Potential soil/sediment contamination issues would need to be considered where soil or sediment removal/disturbance occurs.

Section 2.1.3 Project Descriptions

1. **Mystic River Ecological and Riverbank Restoration Projects – (small scale projects)**

When visiting the Mystic River project corridor, specific locations were identified that would benefit from discreet ecological and riverbank restoration efforts. These projects are smaller in scale, and cumulatively would contribute to greater ecological and human community health along the Mystic River within the project corridor. Because of the discreet nature of these smaller projects, they can be implemented within shorter time frames and require smaller budgets than larger scale projects. Attachment A includes a Locations Plan (Attachment A, Figure 3) for the project corridor, which identifies specific locations for these discreet projects. Attachment D also includes the Mystic River Ecological Restoration and Resiliency Opportunities Table (Opportunities Table), identifying which projects would be applicable to which locations on the Locations Plan. Memoranda 1 through 28 provided project specific information regarding each project type. In this way, BSC is providing preliminary project planning information that can be used to develop specific project proposals as grant opportunities become available.

2. **Flow Management: Amelia Earhart Dam – Increased Upstream Salinity and Tidal Flow, Management of Seasonal Freshwater Flow (large scale project)**

It is assumed that removal of the Amelia Earhart Dam is not feasible, and thus other options for restoration of flow are considered, such as restoration of a tidal cycle and saltwater flushing of the river above the Amelia Earhart Dam. Many areas along and within the Mystic River are populated with common reed (Phragmites australis), and a number of aquatic invasive species (mentioned previously). Allowing restoration of a tidal cycle and saltwater flushing upstream of the Amelia Earhart Dam

Dredging:

Volunteer Opportunities

Science:

Documenting locations of shallow-water shelves prior to project implementation. Monitoring of water temperatures, chemistry, nutrient and pollutant levels, pre and post project, to evaluate changes over time. Assisting with planting of wetland vegetation.

Community:

Hosting community events to fund-raise and generate community support. Design and build signage to explain the science and value of the project.

would reduce or eliminate freshwater invasive species and expand habitat for coastal and marine species, and would have a cooling effect on the river and surrounding areas. The added cooling effect would enhance both ecological and human community climate resiliency. Areas currently supporting common reed could be restored to salt marsh. Anadromous fish, such as alewife (Alosa pseudoharengus) and blue back herring (Alosa aestivalis), would benefit from increased salinity levels and cooler water temperatures in upper reaches of the Mystic River, as well as improved access through the Amelia Earhart Dam.

This could be done through management of the locks to allow greater tidal and freshwater exchange. As part of this, a more thorough understanding of the river's hydrology and hydraulics, and sediment transport will be required.

Working collaboratively with stakeholders and property owners, MyRWA could develop a Mystic River flow management plan that more closely resembles natural annual flow regimes for the Mystic River. Restoration of a tidal cycle upstream of the Amelia Earhart Dam could contribute to partial restoration of more natural riverine flow dynamics and facilitate better fish passage at the dam, as well as better anadromous fish survival rates once past the dam, particularly if combined with management of seasonal freshwater flow to more closely mimic naturally flowing rivers. Allowing greater spring flows that at least partially mimic the spring seasonal peak flows could help restore more natural river sediment movement (thus helping to restore the river bottom profile and potentially reducing the need for channel dredging), as well as potentially reducing water temperature impacts associated with current conditions.

3. River Channel Dredging, Re-Distribution of Sediments and Wetland Restoration/Creation (large scale project)

In numerous areas within the Mystic River channel, sediment appears to have accumulated and formed shallow shelves along the sides of the river. Water in these areas can be just a few inches deep, is more easily warmed, and yet is too deep to allow for the development of wetland vegetation. Sediments from the channel, from some of these shallow areas, or from portions of the shallow areas, could be dredged, and redistributed. Sediments could be placed on some of the shallow shelf areas, raising parts of the shelves closest to the banks and allowing wetlands to develop, while creating cooler, deeper water habitat (thus increasing climate resiliency) where dredging occurred. This approach to channel dredging and wetland creation has been utilized successfully by the US Army Corps of Engineers (US ACE) (Berkowitz J. N., 2014) (Berkowitz J. L., 2016), and results in cooler, deeper river channels, increases wetland ecosystem services, and leads to lower sediment disposal costs than offsite sediment disposal.

Floodplain Restoration
Volunteer Opportunities

Science:

Monitoring changes in vegetative communities, pre and post project.

Community:

Hosting community events to fund-raise and generate community support. Design and build signage to explain the science and value of the project.

The US ACE also uses dredged materials to develop instream wetland islands by depositing dredged sediment just upstream of a shoal or island, in a manner consistent with the principles of Engineering With Nature (Berkowitz J. B., 2015) (Berkowitz J. L., 2016) (Berkowitz J. N., 2014). The US ACE defines Engineering With Nature as, "…the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental and social benefits through collaborative processes" (Berkowitz J. N., 2014). In this approach, dredged sediments are released in the river channel, upstream of an area where a natural shoal or an island is forming or has formed. Natural river flow processes then determine the exact placement of the sediments. Where this has been implemented, in-channel islands supporting wetland and floodplain vegetation have formed, river channels are deepened, sediment disposal costs are reduced relative to off-site disposal, in-channel velocities increase (reducing future needs/costs for dredging), and wetland ecosystem services are increased (Berkowitz J. L., 2016) (Berkowitz J. N., 2014) (Berkowitz J. B., 2015). In both of these dredging approaches, researchers have found that the created wetlands associated with channel dredging provide nitrate removal and nutrient cycling ecosystem services, thereby improving river water quality (Berkowitz J. L., 2016).

In addition to the generalized planning and permitting processes identified in Sections 2.1.1 and 2.1.2, implementation of projects #1 and #2 and #3 would likely require, at a minimum:

- **a.** evaluation of changes to floodplain and floodway, evaluation of impacts to upstream and possibly downstream properties,
- **b.** detailed assessment of, and planning for, ecological and hydrologic transition,
- **c.** monitoring of ecological and hydrologic transition, impacts to upstream and downstream properties, and post-transition conditions.
- **d.** evaluation of potential need for post-transition adjustments to salinity and flow increases.

4. Floodplain Restoration (small to large scale projects)

Historical aerial photographs and USGS topographic maps (See Attachment B) provide insight into how extensive Mystic River floodplain and floodplain wetlands were, prior to development. Much of the floodplain has been elevated with the placement of fill, and the river channel itself has been straightened. Floodplain restoration would entail the removal of floodplain fill, and the restoration of pre-existing floodplain elevations and wetlands, as well as functional connection to the river channel. A large scale project in this regard is dependent upon the availability (i.e. land ownership and level of development) of potential sites for floodplain restoration. Much of the land that is managed by DCR is filled floodplain (See Attachments A and C). Working collaboratively with DCR and other

Riverbank Restoration

Volunteer Opportunities

Science:

Monitoring changes in vegetative communities, water temperature, chemistry, nutrient and pollutant levels, pre and post project (if project scale is large enough).

Community:

Hosting community events to fund-raise and generate community support. Design and build signage to explain the science and value of the project.

property owners, as well as with other stakeholders and community members, project(s) could be developed to remove fill and restore floodplain. The scale of such projects could range from relatively small scale (Attachment D) to a more comprehensive large scale effort.

5. Riverbank Restoration (small to large scale projects)

Allowing the Mystic River to move naturally within its floodplain is not a viable option because land uses adjacent to the Mystic River are built-out and dense. As a result, other alternatives are considered. Many banks along the Mystic River are either eroded or armored. Bank restoration, like floodplain restoration, could occur as relatively small scale projects (See Attachment D), or as a more comprehensive effort. Armored banks could be replaced or amended with a variety of softer solutions for bank stabilization, such as installation of live fascines, coir logs, tree trunks and root masses. Alternatively, should shallow-water shelf areas (currently within the river) be converted to wetland, a new river bank would form or be constructed on the water side of the new wetland, and the old armored bank could be supplemented with topsoil and plantings, without the need to remove the stone armoring. Engineering will be required to fully evaluate this option.

6. Watershed Restoration and Climate Resiliency (small to large scale projects)

Although this project scope was limited to a 4-mile river corridor (see Attachment A, Figure 2), it is recommended that the entire watershed be considered in an effort to improve the ecological function and climate resiliency of the lower watershed. MyRWA and others are engaged in green infrastructure, water quality improvement, low impact development, and other sustainable practices throughout the watershed. Sustainable practices for improving water quality, reducing stormwater impacts, reducing pollutant and nutrient inputs to the river, reducing impervious surfaces, and increasing the natural cover within the watershed, cumulatively and over time, will contribute to the restoration of ecosystem, riverine, and human health, sustainability, and climate resiliency in the lower watershed as well as the upper watershed. In addition to continuation of existing efforts, the following is recommended:

a) Climate Resiliency Assessment (larger scale, with implications for smaller scale projects)

Using The Nature Conservancy's (TNC) "Resilient and Connected Landscapes for Terrestrial Conservation" GIS datasets, as well as the North Atlantic Landscape Conservation Cooperative's Databasin Index of Ecological Integrity dataset, the ecological climate resiliency within the Mystic River Watershed was evaluated. In addition, the Massachusetts BioMap 2 dataset within the Mystic River Watershed was used to further evaluate

> biological condition. Attachment E provides the resulting maps, which indicate areas within the watershed that provide the greatest level of ecological climate resiliency, regional connectedness (termed "regional flow"), and ecological and habitat integrity, and are most likely to continue to do so in the coming decades. These datasets are based upon an evaluation of geologic setting, landform diversity, local connectedness, regional connectedness, and biological condition/ecological integrity. TNC's website http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/Pages/default.aspx provides a detailed explanation of methods and the science behind this mapping tool. Additionally, the TNC "Resilient Sites for Conservation in the Eastern United States" fact sheet and their "Terrestrial Resilience Core Concepts" information page from their website are included in Attachment E. These fact sheets provide an explanation of the ecological concepts and science that underlie the TNC datasets. Mapping of ecological climate resilience (Figure 4), regional flow (regional connectedness) (Figure 5), and ecological integrity (Figure 6) is based on relative scores for locations on the landscape. In Figures 4 and 5, areas of similar geophysical setting are compared to each other, within the larger ecoregion, and are ranked based on how far below or above average they are (in standard deviations). In Figure 6, ecological integrity is scored on a relative scale ranging from 0 to 1. The Ecological Integrity Index Map was created by researchers at the University of Massachusetts, Amherst, and is hosted on the North Atlantic Landscape Conservation Cooperative website: https://nalcc.databasin.org/datasets/3b455d5c326041dbb3d1ca6e4c5a43c2.

The Massachusetts Natural Heritage and Endangered Species program provides the following definition of BioMap2 at http://maps.massgis.state.ma.us/dfg/biomap2.htm :

> BioMap2 is designed to guide strategic biodiversity conservation in Massachusetts over the next decade by focusing land protection and stewardship on the areas that are most critical for ensuring the long-term persistence of rare and other native species and their habitats, exemplary natural communities, and a diversity of ecosystems. BioMap2 is also designed to include the habitats and species of conservation concern identified in the State Wildlife Action Plan.

The Mystic River watershed maps based on the TNC datasets identify specific areas that are anticipated to provide greater climate resiliency than surrounding areas, as outlined above. By referencing these maps, MyRWA and others can prioritize conservation and ecological restoration of higher value areas, and, if possible, the areas that connect relatively resilient sites. By identifying corridors of connectivity between larger areas of resiliency, land managers can enhance the resiliency of the watershed and provide species with a combination of ecological refuges and routes allowing movement on the landscape to find tem-

perature and moisture alternatives. Additionally, identification of areas with higher levels of climate resiliency can provide additional justification for funding conservation and ecological restoration efforts in these areas and adjacent areas.

Figures 4 and 4A – Ecological Climate Change Resiliency Score Maps

Despite being a heavily populated and developed watershed, the Mystic River watershed includes some areas that score in the slightly above average (0.5 – 1 Standard Deviation (SD), above average (1 to 2 SD), and far above average (> 2 SD) categories for ecological climate change resilience. Not surprisingly, these areas are clustered in the vicinity of the Middlesex Fells Reservation, Horn Pond Recreation Area, and Belle Isle Marsh Reservation. Additionally, although most of the watershed is categorized as developed, a number of average (0.5 to -0.5 SD), slightly below average (-0.5 to -1 SD), below average (-1 to -2 SD) and far below average (< -2 SD) areas are identified throughout the watershed, including land within the 4-mile Project Corridor and in the vicinity of the Lower and Upper Mystic Lakes. These areas likely include land that is not developed, but has been degraded in some manner.

Opportunities:

1. Identification of the few remaining areas with above average or greater ecological climate resiliency (vicinity of the Middlesex Fells Reservation, Horn Pond Recreation Area, and Belle Isle Marsh Reservation) in the Mystic River watershed creates an opportunity to evaluate these areas for projects that support ecological restoration for greater ecological function and climate resiliency. Each of these areas contains land that is ranked at average to below average resilience, as well as land that is ranked higher. Evaluation of opportunities to enhance ecological functioning and climate resiliency at each of these areas is recommended, and use of the TNC resilience map provides science-based documentation of both the need for and the importance of community and financial support in this regard. Additionally, as can be seen in Figure 4A, the Middlesex Fells Reservation is one of the few relatively large undeveloped areas with average or greater ecological climate resiliency. Because ecologically resilient (average or greater) land is so limited within the metro-Boston area, the importance of protecting and restoring the few remaining relatively large areas is all the more important.
2. Several areas within the 4-mile Project Corridor along the Mystic River are identified as having below average or far below average climate resiliency, including Wellington Marsh (Figure 3, #18-8A), other parts of Torbert-Macdonald Park (Figure 3, #18), land in the vicinity of the Lower Mystic and Upper Mystic Lakes, Figure 3, #6, #17, and other locations). These rankings provide science-based documentation of the importance of prioritizing climate-resilient ecological restoration projects in these areas.

3. Additional areas (outside of the 4-mile Project Corridor) are identified as having below average or far below average climate resiliency within the Mystic River watershed. This mapping can be utilized to identify further opportunities within the watershed for climate-resilient ecological restoration projects, and this mapping can be utilized to provide science-based documentation of the rationale for community and financial support.

Figure 5 – Regional Flow Map

TNC's Regional Flow Map indicates locations on the landscape where species have opportunities for easier or more difficult passage from one area to another, and is a measure of landscape connectivity. Not surprisingly, movement for non-human species across the landscape in the highly developed Mystic River watershed is difficult, with internal movement at the Middlesex Fells Reservation being the exception. Middlesex Fells Reservation is the only location within the watershed that offers species greater than average flow (i.e. movement) across the landscape. This further highlights the importance of supporting ecological restoration at the Middlesex Fells Reservation.

Figure 6 – Ecological Integrity Index Map

The Ecological Integrity Index Map indicates that Middlesex Fells Reservation is the only location within the watershed that offers species greater than average ecological integrity. This further highlights the importance of supporting ecological restoration at the Middlesex Fells Reservation. Other areas within the watershed are ranked as average to low, with regard to ecological integrity. Lower than average rankings may provide justification in investing in substantive ecological restoration projects, such as those along the 4-mile Project Corridor, lower than average areas within the Middlesex Fells Reservation, Horn Pond Recreation Area, and Belle Isle Marsh Reservation, as well as others.

Figure 7 – Climate Resiliency Co-Occurrence Map

A Climate Resiliency Co-Occurrence Map was prepared for the Mystic River Watershed. This map indicates locations where one, two or three of the climate resiliency maps (Figures 4, 5, and 6) overlap, or co-occur. This allows the viewer to easily identify areas on the landscape where several high value characteristics co-occur. The three figures used for this co-occurrence map were weighted equally during modelling, and areas were included only if they were ranked "average" or higher on the underlying maps. Areas where all three maps of ecological climate resiliency co-occur include Middlesex Fells Reservation, Horn Pond Recreation Area, and Belle Isle Marsh Reservation, as well as a few other smaller areas in the upper watershed. Two maps co-occur in a few locations along the 4-mile Mystic River Project Corridor. This mapping provides additional support for climate-resilient ecological restoration projects in the areas identified as having multiple indicators of climate resiliency.

Figure 8 – BioMap2 Data Map

The BioMap2 Data Map indicates areas of BioMap2 Core Habitat and BioMap2 Critical Natural Landscape. Only one area of Core Habitat is indicated within the 4-mile Project Corridor. The Middlesex Fells Reservation, Horn Pond Recreation Area, and Belle Isle Marsh Reservation are all shown as including Core Habitat and Critical Natural Landscape, further highlighting the importance of proactive restoration and stewardship of these areas. Additionally, a few other areas are shown as either Core Habitat or Critical Natural Landscape, within the watershed. These designations provide science-based documentation of the ecological importance of these specific locations within the watershed, and can provide justification for community and financial support in this regard. It is significant that such a highly developed watershed continues to support some areas with these important habitat designations.

The Massachusetts Natural Heritage and Endangered Species Program, at http://maps.massgis.state.ma.us/dfg/biomap2.htm, provides the following definitions for BioMap2 designations in Massachusetts:

Core Habitat totals 1.2 million acres, of which 680,000 acres remain unprotected.

Core Habitat includes:

- Habitats for rare, vulnerable, or uncommon mammal, bird, reptile, amphibian, fish, invertebrate, and plant species
- Priority Natural Communities
- High quality wetland, vernal pool, aquatic, and coastal habitats
- Intact forest ecosystems

Critical Natural Landscape totals 1.8 million acres, of which 1 million acres remain unprotected.

Critical Natural Landscape includes:

- The largest Landscape Blocks in each of 8 ecoregions
- Adjacent uplands that buffer wetland, aquatic, and coastal habitats

b) Upper Watershed/Headwater Stream Restoration (small to larger scale)

Consistent with the principles of ecological restoration, researchers such as Denise Burchsted (Burchsted, 2010) have documented that the natural condition for streams, particularly upper watershed headwater streams, is not a "free-flowing" condition, but instead involves numerous small, leaky, in-stream dams and obstacles, composed of downed wood, rocks, leaves, and beaver dams. Streams in this condition tend to be connected to their floodplains to a much greater extent than "free-flowing" streams. This stream morphology contributes to the retention of floodwater in the upper reaches of the watershed, thus reducing peak flows and extending

the duration of streamflow. Such a stream morphology provides enhanced fish habitat and ecological function, maintains or restores stream-floodplain connectivity, and provides climate resiliency by mitigating flood and drought conditions. MyRWA should look for opportunities in the upper watershed to restore stream-floodplain connectivity by restoring natural stream morphology in this manner. As with other project ideas, stakeholder, property owner, agency, and community involvement would be an essential ingredient to project success.

7. Invasive Species – Alternative Approach (small to larger scales)

MyRWA has led extensive and successful volunteer efforts to hand-pull water chestnut and other aquatic invasive species from the Mystic River. DCR has supported and continues to support significant efforts to combat invasive species through a combination of cutting and spraying with herbicides. Another approach that has been successful in other projects is use of grazing animals to combat invasive species. Grazing avoids the use of chemical herbicides, and reduces human labor, but would also require a feasibility analysis to determine the impact of grazing animal manure (could be positive, neutral or negative) and the appropriateness of specific grazing species for specific invasive species and project locations, and a cost comparison with other invasive species control methods. Grazing could be applied on small to larger scales, and again, would require collaboration with stakeholders, property owners, agencies, and communities. Grazing could be a strong social asset when combined with a community outreach and education program (as an attraction for schoolchildren and families with young children). Alternatively, if not presented to the community in a thoughtful way, community members could perceive grazing animals negatively (manure, odor, etc.).

Section 3.0 - Conclusions

The Mystic River corridor and surrounding watershed has been highly valued, developed and used by humans for centuries, if not millennia, and as a result, has supported ever-denser human communities. With greater understanding of the challenge that climate change presents us, and advances in the science of ecological restoration, the importance of, and opportunities for, climate-resilient ecological restoration of riparian corridors such as the Mystic River corridor and surrounding watershed has never been clearer. This report is intended to facilitate implementation of projects that will lead to durable, climate-resilient ecological restoration and sustained improved ecological function of the Mystic River corridor, surrounding watershed and communities. It is also hoped that this report will complement existing efforts and reports, in achieving these goals.

Priorities

The restoration opportunities and projects discussed in this report have been prioritized. The Opportunities Table in Attachment D ranks specific small scale projects based on their appropriateness for a given location. This table can be referenced to prioritize actions at specific locations. More broadly, both onsite and desktop review of the 4-mile Project Corridor suggests the following priorities for future work:

Small scale projects (referenced in Opportunities Table, Attachment D):

1. Restoration of Wellington Marsh
2. Restoration of riverbank and other natural areas at Torbert-MacDonald Park
3. Restoration of Area 17 (see Figure 3)
4. Restoration of Area 6 (see Figure 3)
5. Restoration of Area 1 (see Figure 3)

These areas have been prioritized for the following reasons. Torbert-MacDonald Park is the largest contiguous area of vegetated publicly-owned land within the 4-mile project corridor and is located immediately adjacent to the river. Therefore, Torbert-MacDonald Park appears to offer the best opportunities for ecological restoration within the project corridor. Within the Torbert-MacDonald Park, Wellington Marsh, is the largest wetland area, and is vegetated with a mix of native and invasive species, yet is not mowed lawn, nor planted with landscape plantings. Area 17 is located north of Torbert-MacDonald Park, is currently undeveloped and grown over with a mix of native and invasive species, and is hydrologically connected to Torbert-MacDonald Park and the Mystic River. Restoration of this relatively large vegetated area in such close proximity to Torbert-MacDonald Park would enhance the ecological value of both areas. Area 6 is a relatively large naturally vegetated (both native and invasive species) area on the northeast edge of the Lower Mystic Lake. It is one of the only areas within the project corridor that supports a relatively large forested area, and provides a natural buffer to both the Lower Mystic Lake and the Mystic River. Area 1 is one of the larger grassed areas immediately adjacent to the river, and as such, provides a relatively large area for ecological and streambank restoration.

Within the Opportunities Table in Attachment D, the selection of project types is derived from our assessment of feasibility, context, and impact. Feasibility is assessed by identifying a lack of impediments to modification of the site, what sort of equipment can be used, and what physical and social constraints affect the alteration of the site. Context is assessed by evaluating onsite and adjacent vegetation, proximity to the river, soil volumes/slopes, infrastructure and human activities. Impact is assessed by evaluating the potential for creation of habitat, improvement of water/soil quality, and public engagement.

Large scale projects

1. Flow management (Section 2.1.3(2)) of the Mystic River
2. Mystic River channel dredging, re-distribution of sediments, and wetland/ riverbank restoration (Section 2.1.3(3) and (5))
3. Restoration of ecologically high-value locations (Middlesex Fells Reservation, Horn Pond Recreation Area, Belle Isle Marsh Reservation, and vicinity of Lower and Upper Mystic Lakes) (Section 2.1.3(6)A)
4. Upper Watershed/Headwater Stream Restoration (Section 2.1.3(6)B)

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Berkowitz, J. N. (2014). Use of strategic placement of dredged sediments to support Horseshoe Island in Atchafalaya River, Louisiana: A preliminary ecological survey. US Army, Engineer Research and Development Center.

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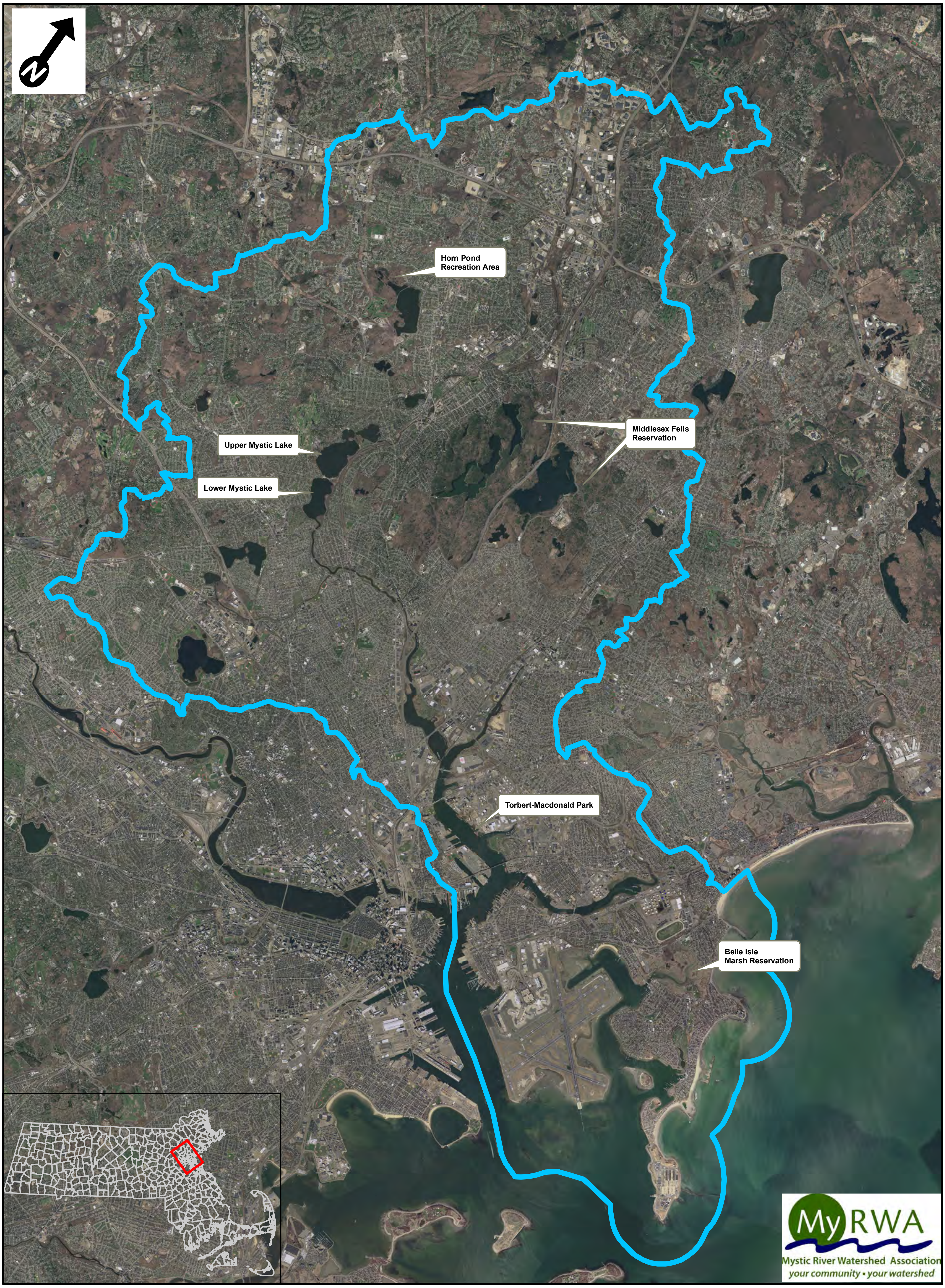
Attachment A

Mystic River Watershed Association
Climate-Resilient Riverbank and Ecological Restoration Planning Project

Climate-Resilient Riverbank and Ecological Restoration Planning Report

FIGURES



Scale:

1 inch = 7,000 feet

0 6,500 13,000

Feet

MYSTIC RIVER WATERSHED

Figure 1
Locus Map

Massachusetts

Source:
-MassGIS: Basemap & Environmental Data
-Aerial & Topo Imagery: ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

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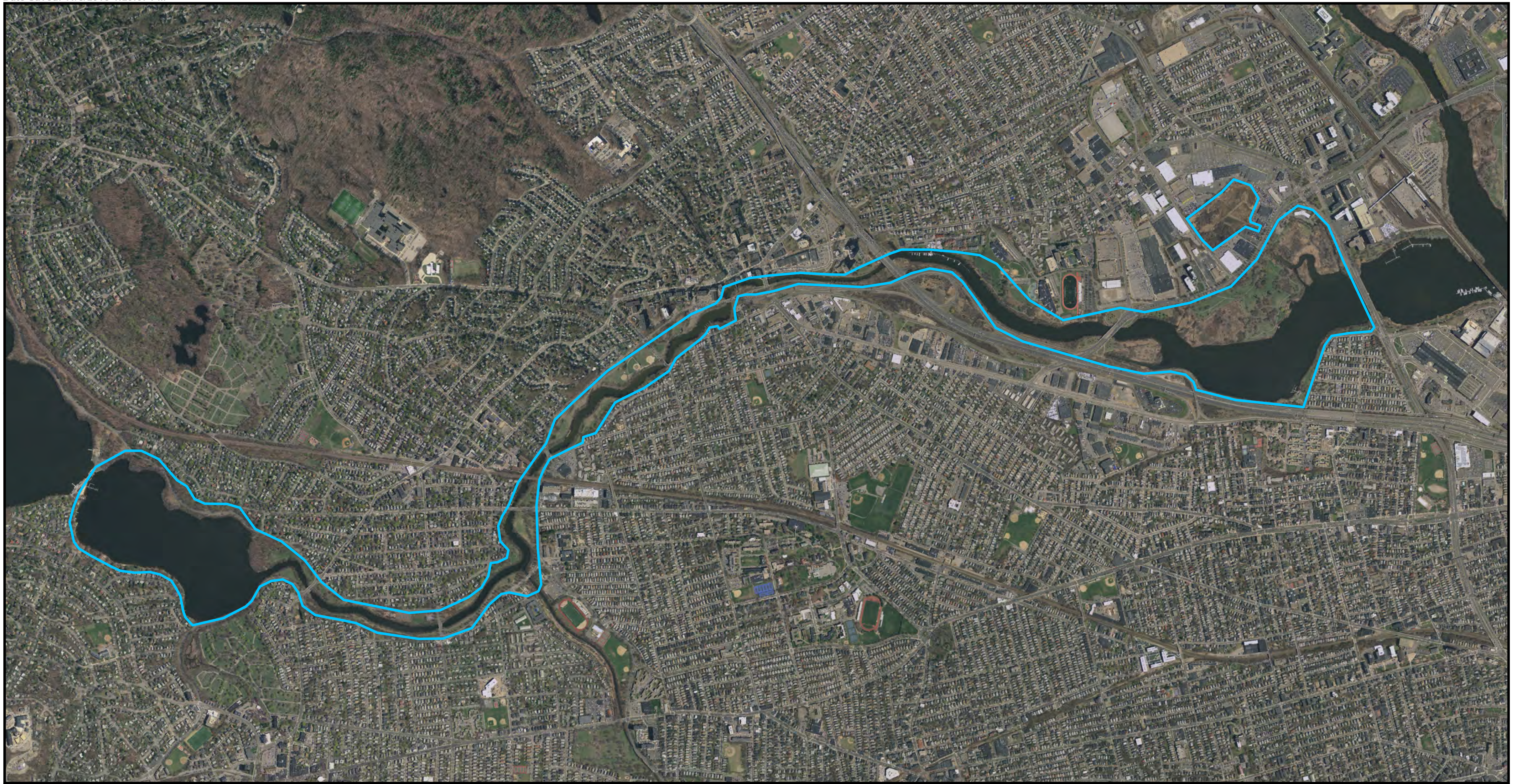
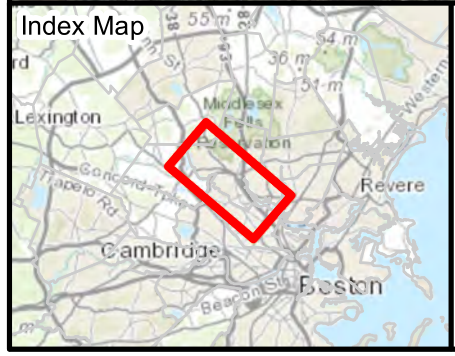


Index Map



Legend

4 Mile Project Corridor

N

1 inch = 1,500 feet

0 1,500 3,000

Feet

Source:
-MassGIS
Basemap & Environmental Data
-Aerial & Topo Imagery
ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

MYSTIC RIVER WATERSHED

Figure 2
4 Mile Project Corridor

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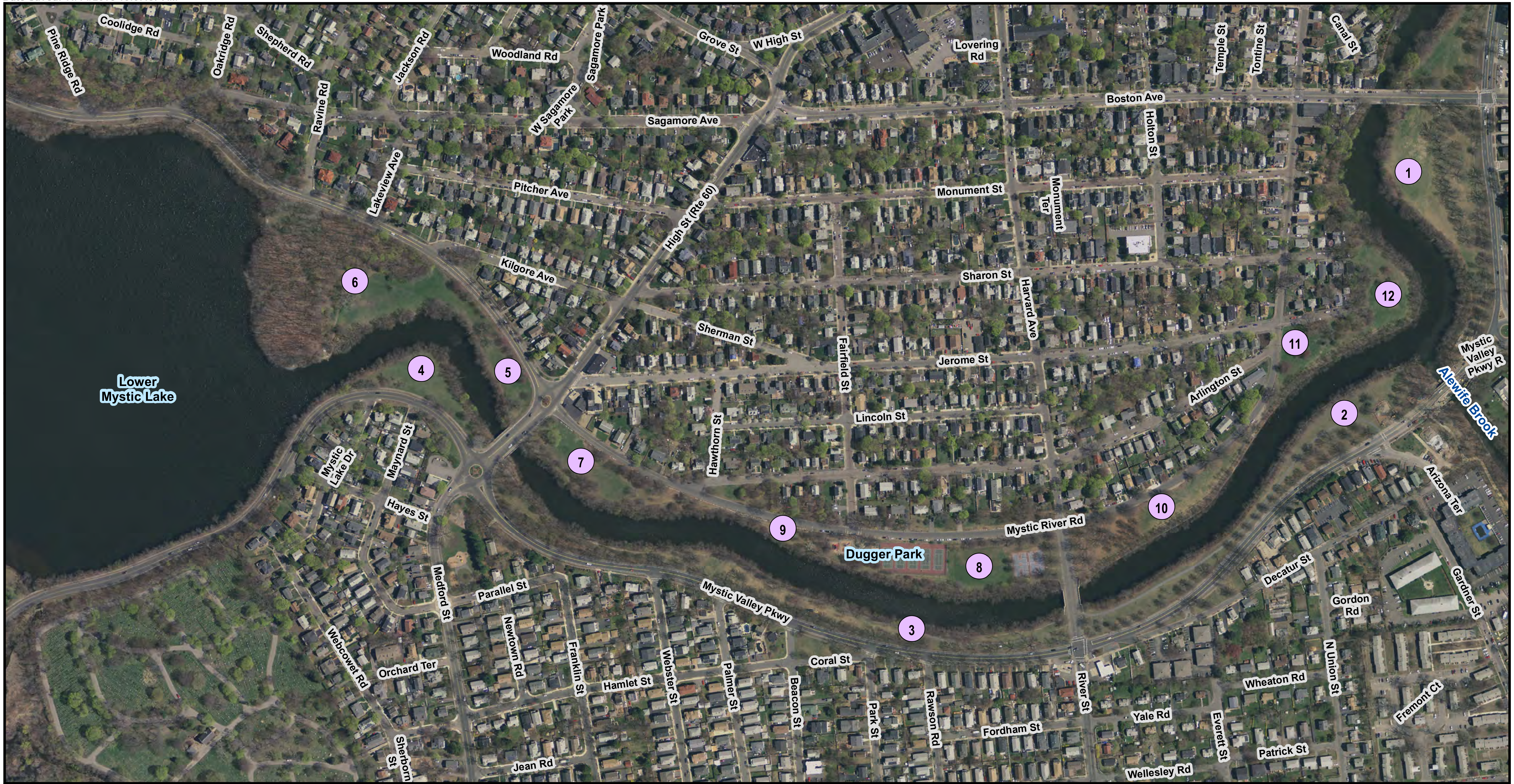

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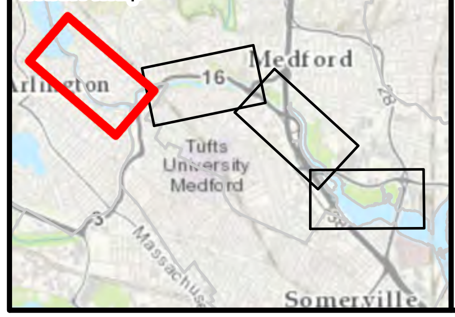

Legend

/ Potential Ecological and Riverbank Restoration Locations

N

1 inch = 350 feet

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Feet

Source:
-MassGIS
Basemap & Environmental Data
-Aerial & Topo Imagery
ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

MYSTIC RIVER ECOLOGICAL AND RIVERBANK RESTORATION OPPORTUNITY LOCATIONS PLAN

FIGURE 3

Somerville, Medford & Arlington, MA
Page 1 of 4

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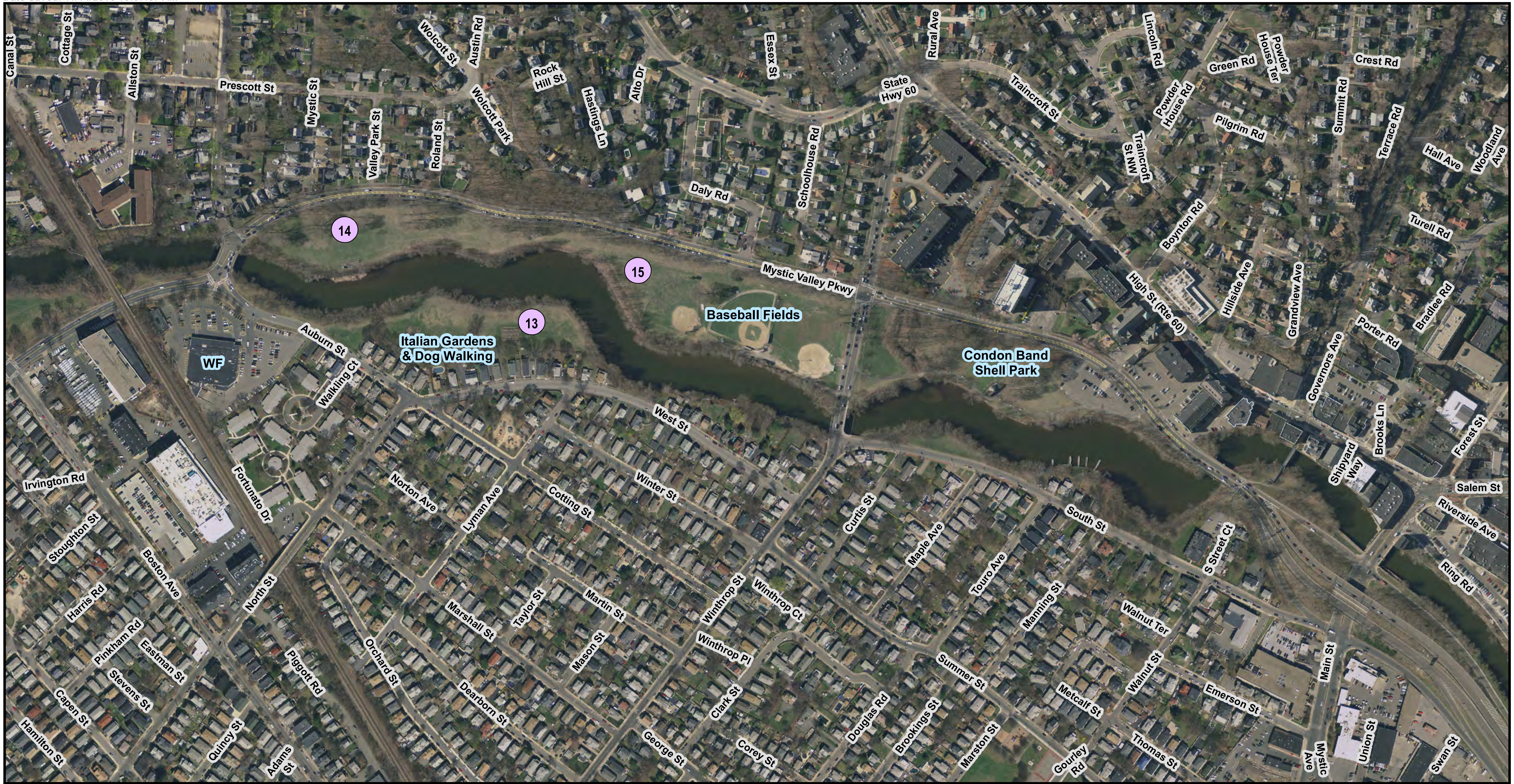

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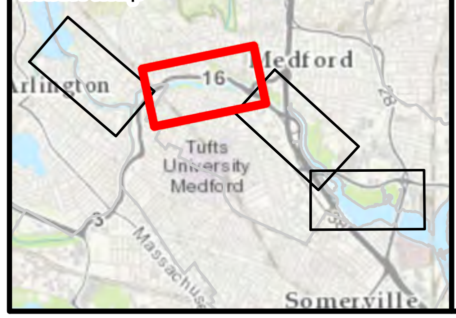

Legend

Potential Ecological and Riverbank Restoration Locations

N

1 inch = 350 feet

0 350 700

Feet

Source:
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Basemap & Environmental Data
-Aerial & Topo Imagery
ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

MYSTIC RIVER ECOLOGICAL AND RIVERBANK RESTORATION OPPORTUNITY LOCATIONS PLAN

FIGURE 3

Somerville & Medford, MA

Page 2 of 4

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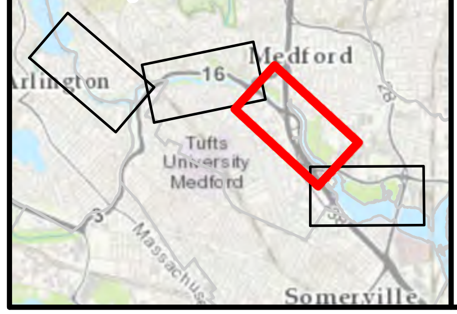

Legend

Potential Ecological and Riverbank Restoration Locations

1 inch = 350 feet

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Feet

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Source:
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Basemap & Environmental Data
-Aerial & Topo Imagery
ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

MYSTIC RIVER ECOLOGICAL AND RIVERBANK RESTORATION OPPORTUNITY LOCATIONS PLAN

FIGURE 3

Medford, MA

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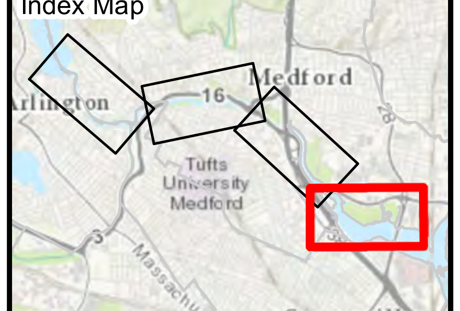
Index Map



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○ / ○ Potential Ecological and Riverbank Restoration Locations

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1 inch = 350 feet

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Feet

Source:
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Basemap & Environmental Data
-Aerial & Topo Imagery
ESRI, DigitalGlobe, GeoEye, i-cubed, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., AEX, GEBCO, USDA, USGS, FAO, NPS, NRCAN, GeoBase, Getmapping, Aerogrid, IGP, IGN, Kadaster NL, Ordnance Survey, ESRI japan, METI, ESRI China (Hong Kong), swisstopo, & the GIS User Community

MYSTIC RIVER ECOLOGICAL AND RIVERBANK RESTORATION OPPORTUNITY LOCATIONS PLAN

FIGURE 3

Somerville & Medford, MA
Page 4 of 4

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Attachment B

Mystic River Watershed Association
Climate-Resilient Riverbank and Ecological Restoration Planning Project

Climate-Resilient Riverbank and Ecological Restoration Planning Report

HISTORICAL PHOTOS AND MAPS

Medford Daily Mercury

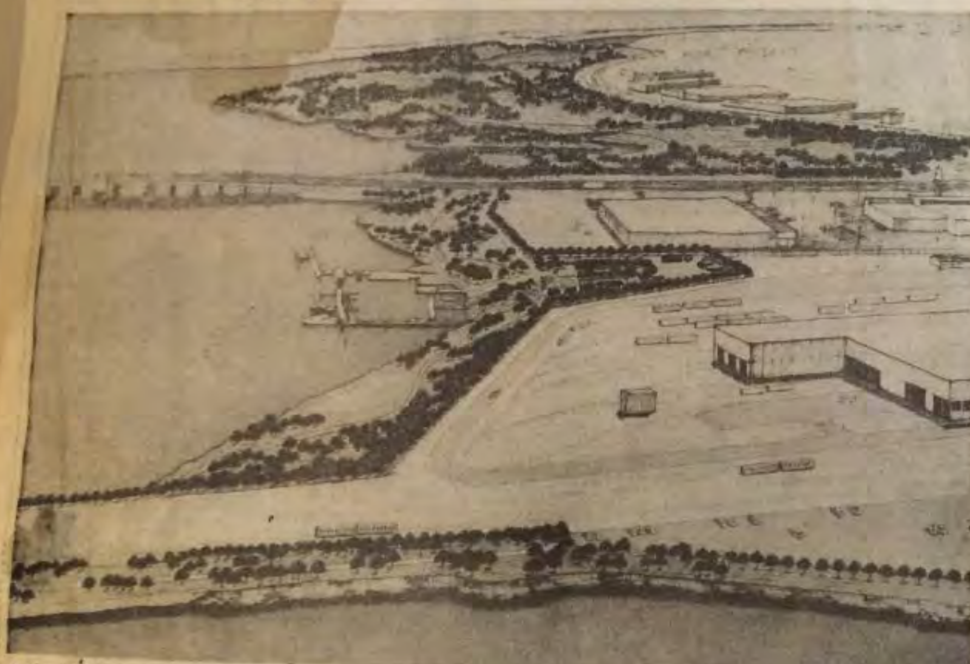
— SINCE 1880, SERVING THE HEART OF THE MYSTIC VALLEY —

1975 — NO. 247 | MEDFORD, MASSACHUSETTS, THURSDAY, DECEMBER 11, 1975 | TWENTY CENTS PER COPY | 20 Pages

River Area Beautification Set

$4 Million MDC Project

By CHARLOTTE B. BERMAN



ARCHITECT'S SKETCH of the Medford side of the planned and proposed areas of the Mystic River Park is shown above, looking west towards Mystic ave. and Medford sq. Body of water in lower portion of sketch is the Malden River adjacent to the new Wellington MBTA transit station, to be included in Phase Two of project. Most of park area shown on west side of tracks running along river, first alongside J. M. Fields to the Fellsway and then along the Mystic Valley pkwy. is included in Phase One currently being advertised. The latter area will include a 70-acre passive park, with a new hill and a sanctuary for wildlife.

BOSTON — A $4 million project, designed to transform a gateway to the Medford-Malden area, the banks of the Mystic River, from barren, decaying grey-brown earth and swamp grass to an inviting vista of paths and greenery is about to be launched by the Metropolitan District Commission.

Bids are due to be opened on Wednesday at the MDC's 20 Somerset st. headquarters on the new Mystic River Park, an expanse of riverfront park land which will run from the Amelia Earhart Dam, between Somerville and Everett, along the Mystic River to the outskirts of Medford sq.

Announcement of the project was made by MDC Commissioner John F. Snedeker. It is part of what will someday be a 200-acre parkland complex.

The MDC hopes it will be followed by a second phase project, costing possibly $2.5 million that will include part of the Malden River banks and set the stage for further municipal improvements along the Malden and Mystic Rivers, if this should be desired.

The end result is expected to be the transformation of a presently unattractive and unused area of land and river banks into a desirable recreational facility to serve people of he Metropolitan District.

It will also go a long way toward creating the vast "Mystic River Basin" predicted with construction of the Amelia Earhart Dam 10 years ago.

The plans are a result of the vision of James W. Falck, MDC landscape architect, and work of Carol R. Johnson Associates, MDC consultants for the project.

Two Phases

The first phase will include provision for construction of two yacht clubs, two fishing docks, a 70-acre passive park, an island for wild life, a maze of foot and bicycle paths, two athletic facilities, a small boat landing, four tennis courts, two parking areas, and planting of several thousand trees and shrubs.

The second phase envisions a public boat launch on the Malden River, as well as bicycle and footpaths along the Malden River Bank, near the dam and the new Wellington MBTA station.

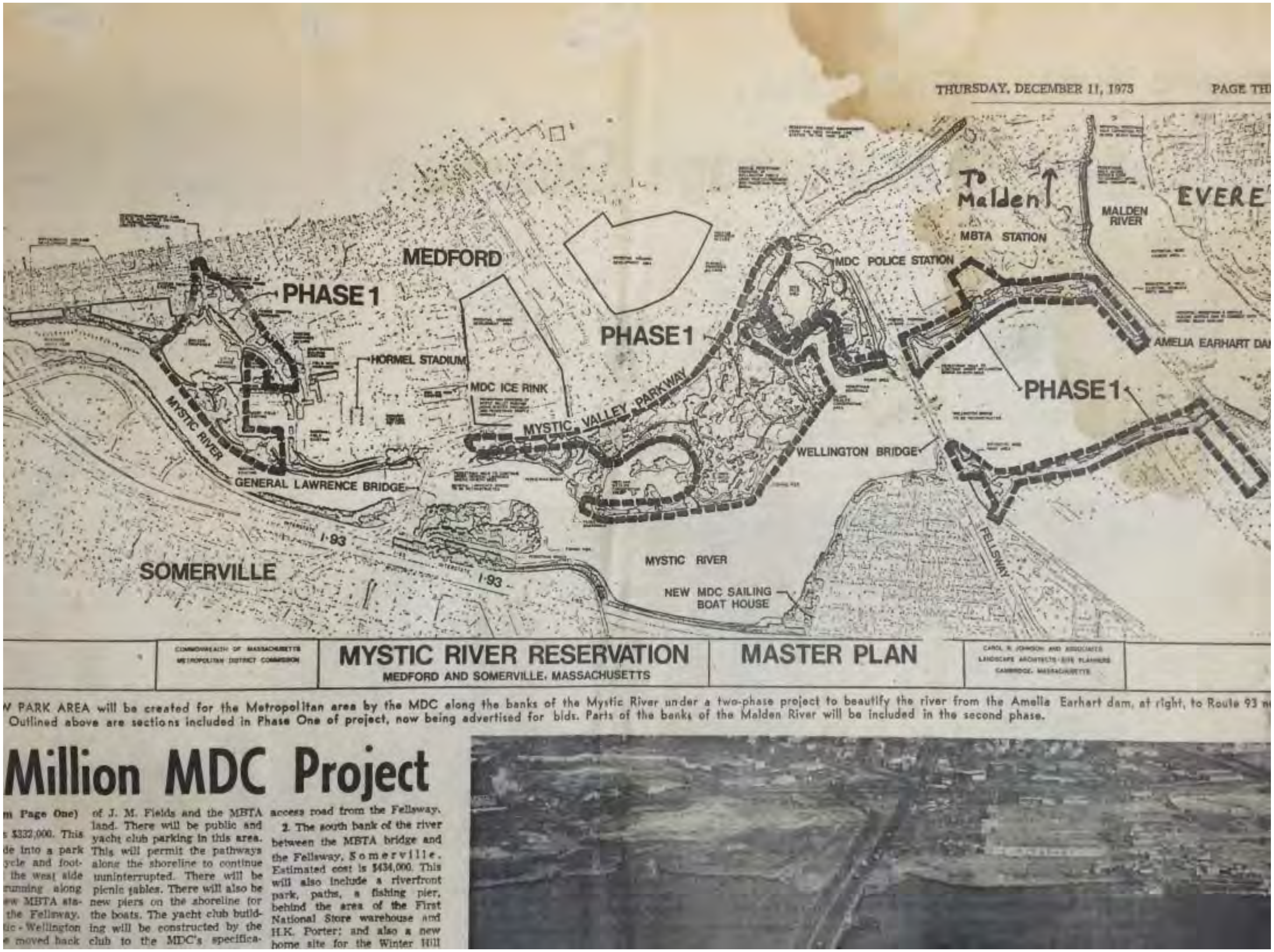
As a major public works project it may also provide some added jobs to the area. The first phase is expected to take two and a half years to complete.

Funding for the current phase is not subject to the current state austerity program, because it is part of a Metropolitan parks allocation in a large 1972 MDC bond issue authorized for environmental outlay.

The "Phase One" project, estimated to cost $1 million, includes the following:

1. The northbank of the Mystic River in Medford between the bridge that carries the MBTA trains to Wellington and the Fellsway at Wellington cir

See $4 MILLION, Page Thirteen



W PARK AREA will be created for the Metropolitan area by the MDC along the banks of the Mystic River under a two-phase project to beautify the river from the Amelia Earhart dam, at right, to Route 93 n Outlined above are sections included in Phase One of project, now being advertised for bids. Parts of the banks of the Malden River will be included in the second phase.

Million MDC Project

m Page One) s $332,000. This de into a park ycle and foot- the west side running along ew MBTA sta- the Fellsway. tic - Wellington e moved back

of J. M. Fields and the MBTA land. There will be public and yacht club parking in this area. This will permit the pathways along the shoreline to continue uninterrupted. There will be picnic tables. There will also be new piers on the shoreline for the boats. The yacht club building will be constructed by the club to the MDC's specifica-

access road from the Fellsway.

2. The south bank of the river between the MBTA bridge and the Fellsway, Somerville. Estimated cost is $434,000. This will also include a riverfront park, paths, a fishing pier, behind the area of the First National Store warehouse and H.K. Porter; and also a new home site for the Winter Hill

MACDONALD PARK AERIAL PHOTOGRAPHS

1938

1955

1969

1925 (Birds-Eye View of Macdonald Park)

1955- USGS (1955-12-01 - 1955-12-05)

1925- View from Somerville to Macdonald Park Unknown Source

USGS MAPS

1893 (Greater Boston)
1903 (Greater Boston)
1946 (Boston North)
1956 (Boston North)
1971 (Boston North

1946 (Lexington)
1956 (Lexington)
1971 (Lexington)

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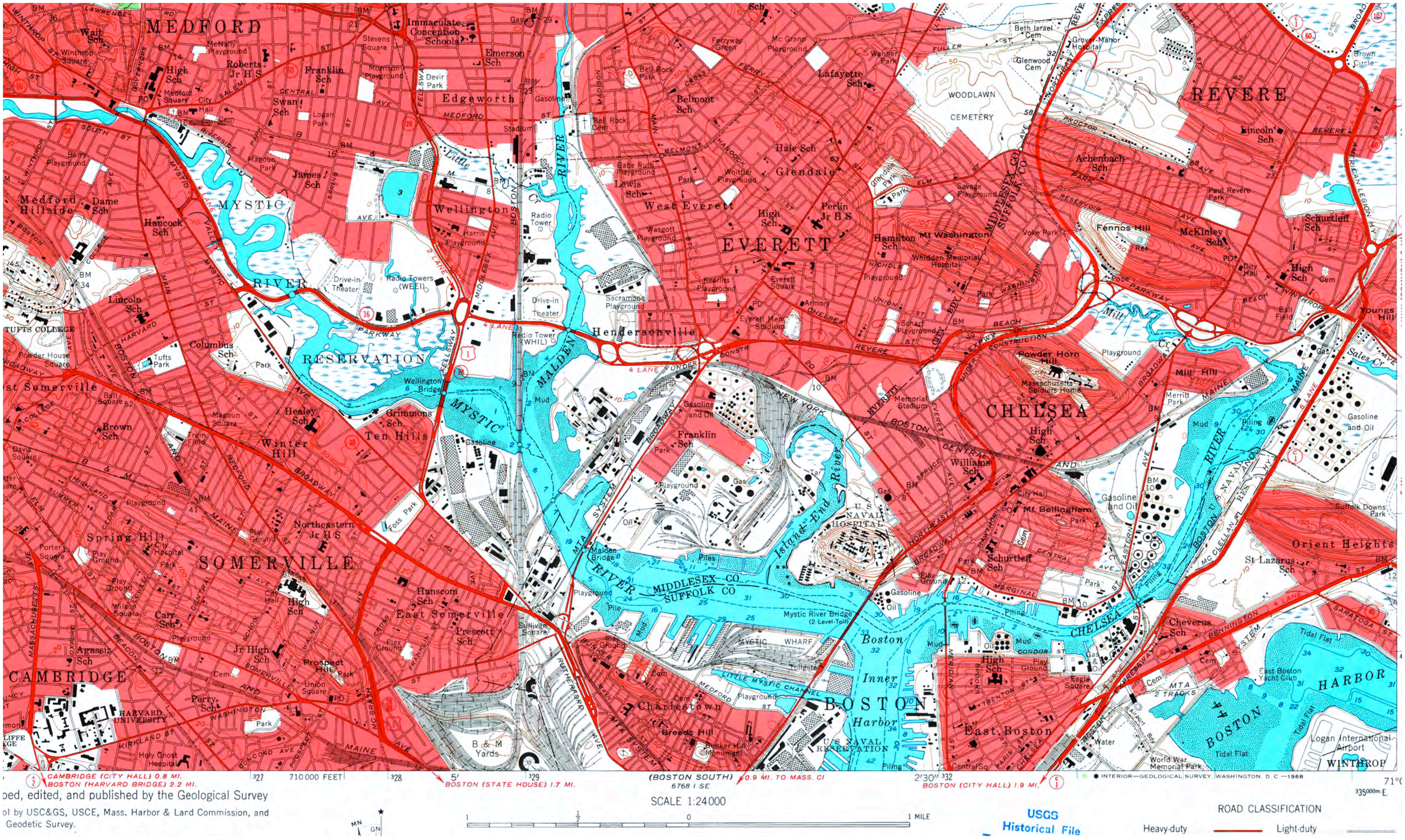
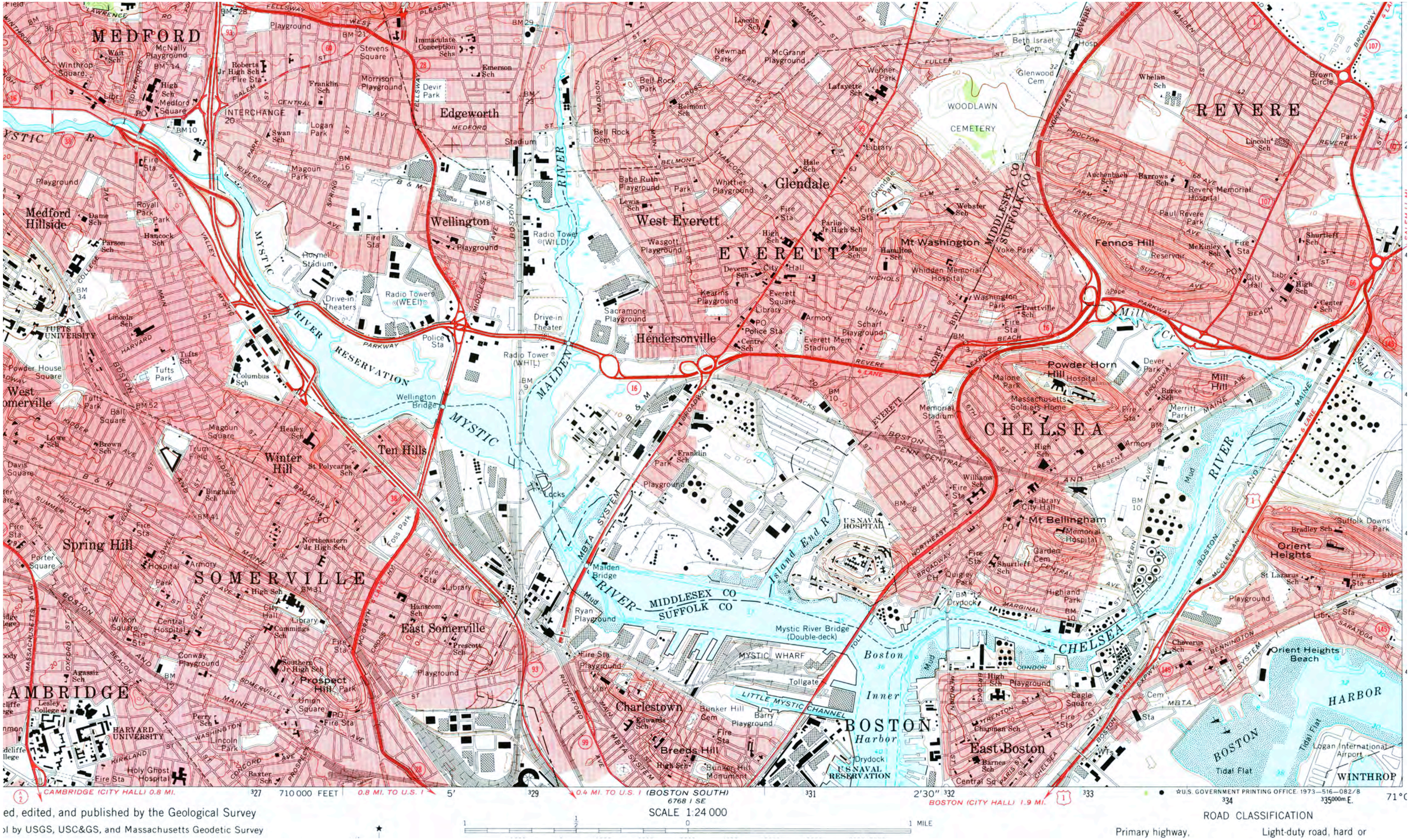
1903- USGS Topo Map, “Boston” (Greater Boston Region)

1893- USGS Topo Map, “Boston” (Greater Boston Region)

1946- USGS Topo Map, “Boston North” (Lower Mystic to Medford Square)

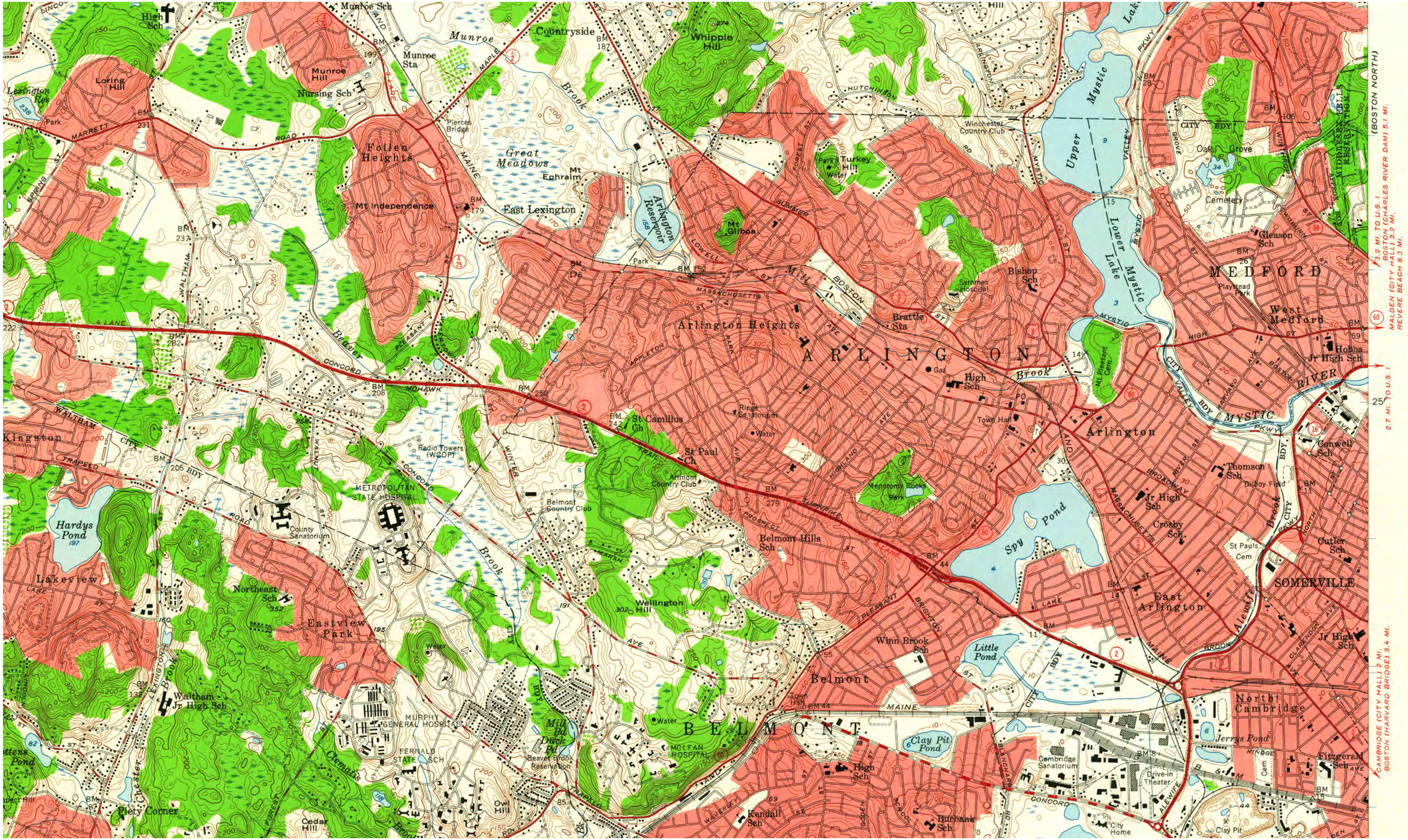


1956- USGS Topo Map, “Boston North” (Lower Mystic to Medford Square)

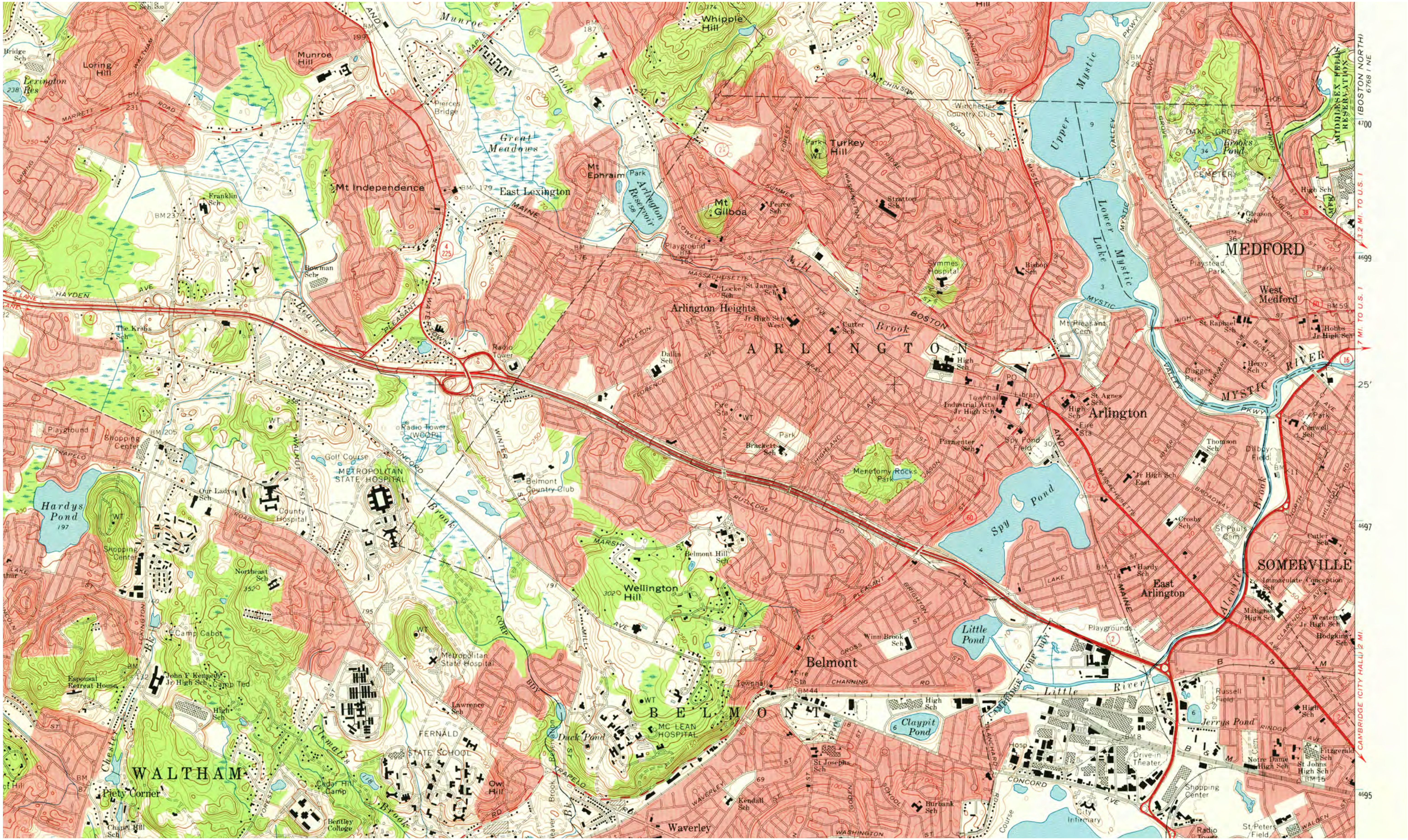


1971- USGS Topo Map, “Boston North” (Lower Mystic to Medford Square)

1946- USGS Topo Map, "Lexington" (Medford Square to Mystic Lakes)



1956- USGS Topo Map, "Lexington" (Medford Square to Mystic Lakes)

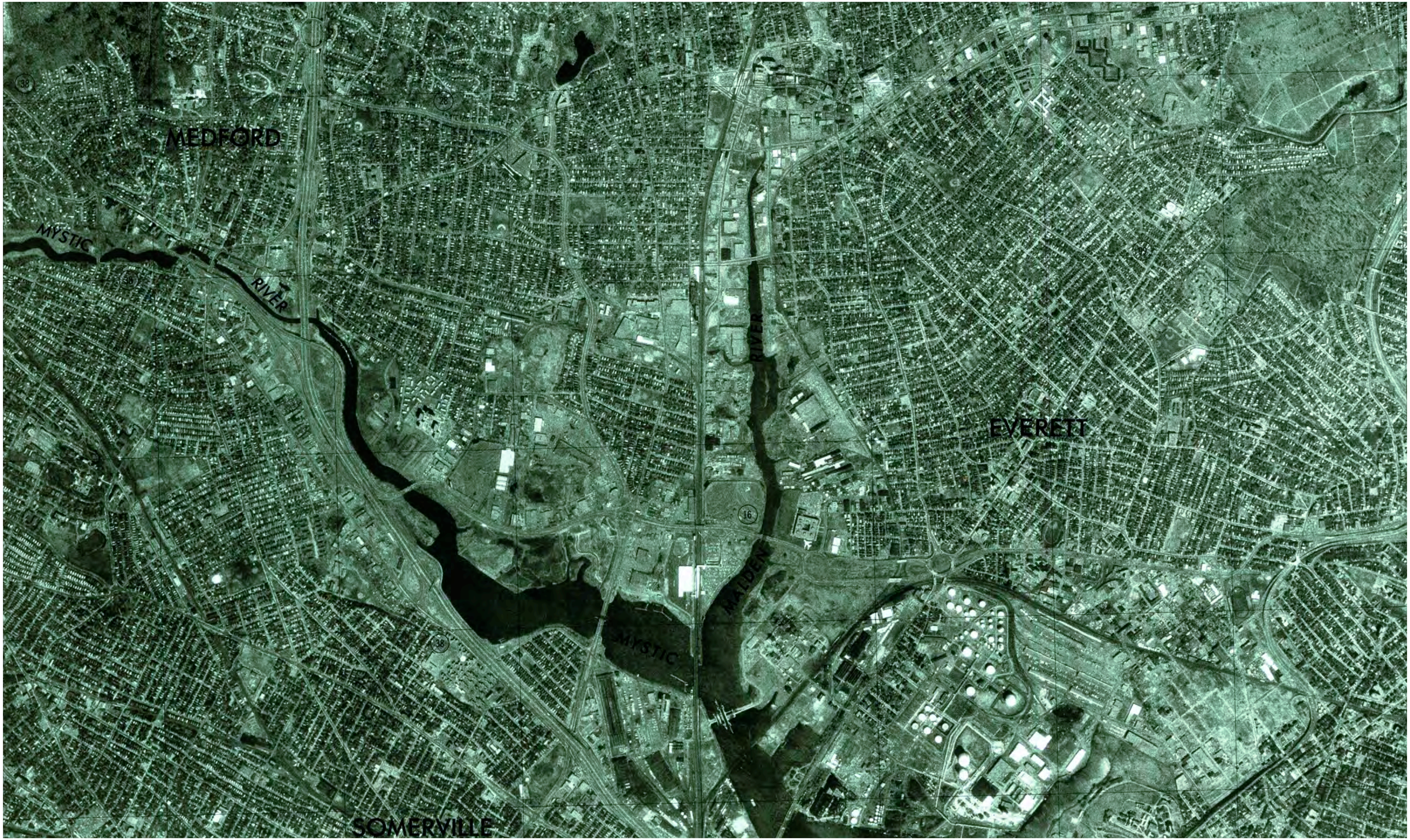


1971- USGS Topo Map, “Lexington” (Medford Square to Mystic Lakes)

USGS ORTHO PHOTOGRAPHS
1938
1955
1969
1925 (Birds-Eye View of Macdonald Park)

1938- USGS (1938-11-01 - 1938-12-22)

1955- USGS (1955-12-01 - 1955-12-05)


MEDFORD
MYSTIC
RIVER
RIVER
EVERETT
16
MALDEN
MYSTIC
SOMERVILLE
1977- USGS

Attachment C

Mystic River Watershed Association
Climate-Resilient Riverbank and Ecological Restoration Planning Project

Climate-Resilient Riverbank and Ecological Restoration Planning Report

PROJECT CORRIDOR PHOTOS – EXISTING CONDITIONS

Photo #1: South side of Mystic River, Mystic River Parkway just west of Boston Ave. Large grassed and under-utilized area.
(Location #1) (Photo Taken: 06/10/16)

Photo #2: South side of Mystic River, Mystic River Parkway between Location #1 and River Street. Large grassed and under-utilized area.
(Location #2) (Photo Taken: 06/10/16)